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METABOLISM OF LIPIDS AND GLUCIDES IN THE WHITE RAT DURING TWO TYPES OF STRESS: FORCED IMMOBILIZATION AND HEAT VARIATIONS

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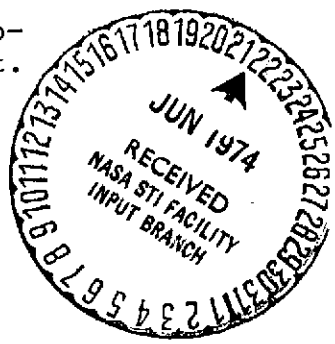
Translation of:"Métabolisme des lipides et des glucides chez le Rat blanc au cours de deux agressions, immobilisation forcée et variations thermiques." In: Comptes rendus des Seances de la Society de Biologie et de ses Filiales, Vol. 166, Oct. 17, 1972, pp. 1277-1283.



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16. Abstract

The authors studied the effects of restraint and sudden variation of environmental temperature on the lipid and glucide metabolism of rats. In the free rat, cooling causes an increase in plasma-free fatty acid content and hyperglycemia. Restraint in animals kept at normal temperature causes a decrease in the plasma-free fatty acid content and an increase in glycemia. A combination of the two stresses does not change the plasma-free fatty acid content but provokes pronounced hypoglycemia and hypothermia.

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METABOLISM OF LIPIDS AND GLUCIDES IN THE WHITE RAT DURING TWO TYPES OF STRESS: FORCED IMMOBILIZATION AND HEAT VARIATIONS

by M. Prioux-Guyonneau and L. Buchel
presented by Jeanna Levy (†)

We have already shown [1] that restraint of the white /1277* rat is a particular type of stress. When applied for two and a half hours at laboratory temperature (22 ±1°C), in contrast to most other types of stresses (emotion, electric shock, exposure to cold) it causes a reduction in the plasma content of the free fatty acids. On the other hand, like other stresses, it causes slight hyperglycemia. Under the above conditions, it is also accompanied by slight hypothermia.

When we examined the effects of restraint on the heat regulation of the rat we found that at ambient temperatures close to that of heat neutrality restraint does not engender hypothermia whereas as at ambient temperatures lower than this the degree of hypothermia is a function of the lowering of environmental temperature [2].

In order to ascertain more closely the metabolic, lipid, and glucide effects on rats subjected to restraint accompanied with more or less pronounced hypothermia we experimented on animals with strained and exposed to ambient temperatures between heat neutrality of the rat and 10°C; we compared the results to those obtained from three animals at the same environmental temperature.

TECHNIQUES

We used 300 female rats of the Wistar strain aged 7 to 8 weeks and weighing 140 to 180 grams fasted but given water

* Numbers in the margin indicate pagination in the foreign text.

† With the collaboration technique of L. Liblau and M. Murawsky.

24 hours prior to the experiment.

We operated on free rats placed in groups of four for two and a half hours in crystalizer and on restrained rats immobilized for two and a half hours in flexible cylinders of metal gauze with the technique already described [3]. The free and restrained animals were kept at ambient laboratory temperature (22 ±1°C) or placed in enclosures at 28, 19, 17, 14, and 10°C, temperatures which progressively lower the body temperature of the animals. /1278

The reduction in ambient temperature is a stress the effects of which may interfere with those of restraint; in order to show adaption reducing or eliminating the effects of this stress we also experimented on free and restrained animals which had already been kept for 10 consecutive days in a 10°C enclosure.

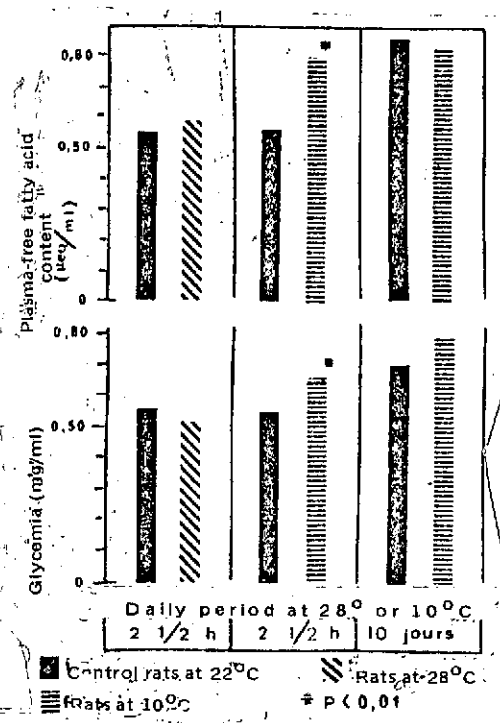

Fig. 1. Plasma free fatty acid content and glycemia. Free rats kept at different ambient temperatures.

We found the rectal temperature by a thermocouple introduced into into the sigmoid, the plasma free fatty acid content by the method of Novac [4], and the glycemia by an enzyme.

test of the true glucose [5]. The plasma free fatty acid content, in particular, undergoes seasonal variation as great as 50%, as Barrett [6] has also observed. For this reason we only included data on comparisons between stressed rats and controlled rats on which experiments were conducted simultaneously.

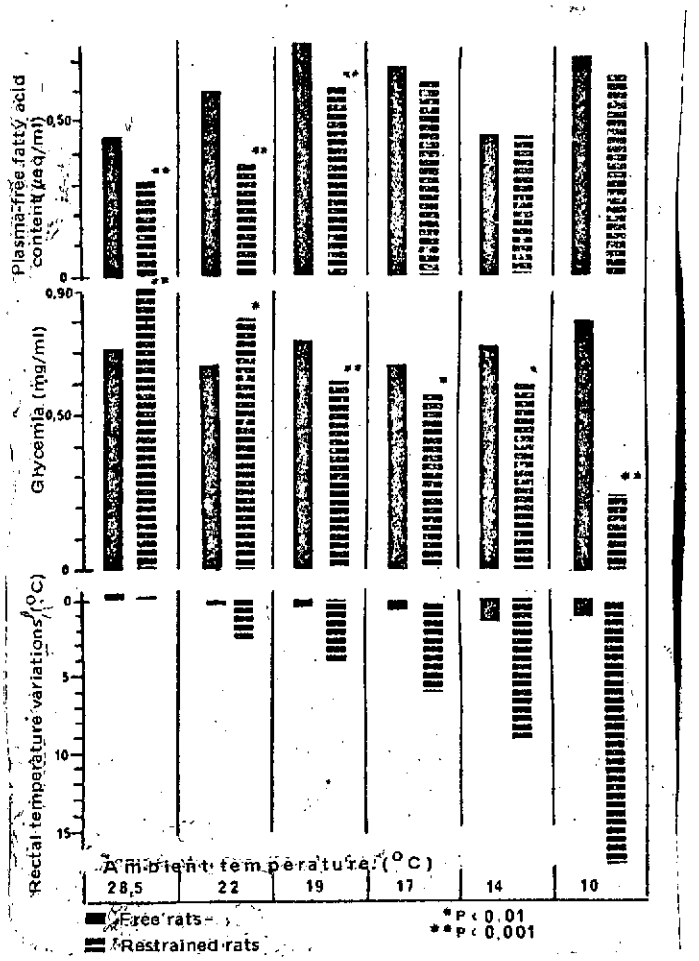

Fig. 2. -- Rectal temperature, plasma free fatty acid content, and glycemia. Free rats and rats restrained for two and a half hours maintained at different ambient temperatures.

The experiments were conducted on groups of 10 or 20 rats; the statistical significance of the results was determined by

by applying the student test.

RESULTS -- Free Rats

Prior to the experiments on restrained animals we specified, on the free rat, the influence exerted only by a stress consisting of environmental heat change. For this purpose, we compared the body temperature, plasma free fatty acid content, and glycemia found from animals exposed for two and a half hours to extreme temperatures from 28 ±1 and 10 ±0.5°C or those which had been maintained at 10°C for 10 days, and of animals maintained at the normal environmental temperature of 22 ±1°C. The results are shown in Fig. 1. /1280

Experimental Conditions	Hypothermia	Plasma free fatty acid content	Glycemia
Free rats exposed 2 1/2 hours to 10°C	±	↗	↗
Restraint 2 1/2 hours at 28°C	0	↘	↗
Restraint 2 1/2 hours at temperatures less than 19°C	+ or ++	0	↘
Free rats kept 10 days at 10°C	0	0	0
Restraint 2 1/2 hours at 10°C after 10 days at 10°C	++	0	↘

Hypothermia; ±36.5°C; +33 to 29°C; ++21°C

↗ increase

↘ decrease

At 28°C, a two and a half hour period changes neither the rectal temperature nor the plasma free fatty acid content nor glycemia. At 10°C, after a two and a half hour exposure the rectal temperature dropped slightly (at 1°C) while the plasma free fatty acid content and glycemia increased from 15 to 20% ($P<0.01$). After 10 consecutive days at 10°C the rectal temperature, plasma free fatty acid content, and glycemia show no significant difference from the control maintained at 22°C.

Restrained Rats

We experimented either on animals maintained normally at 22°C and placed from the beginning of immobilization at different ambient temperatures, 28, 19, 17, 14, and 10°C, or on animals which had been kept in a 10°C enclosure for 10 days before the restraint applied at this same temperature.

To show up the metabolic effects of restraint accompanied and not accompanied by hypothermia, we determined the body temperature, plasma free fatty acid content, and glycemia on both restrained and free rats maintained at the same environmental temperature.

a. Rats kept at 22°C before immobilization (Fig. 2.). -- At an ambient temperature of 28°C, near to the rat's heat neutrality, restraint does not modify body temperature; it causes a decrease in the plasma free fatty acid content ($P<0.001$) and an increase of glycemia ($P<0.001$). /1281

At ambient temperatures less then heat neutrality, i.e., 23, 19, 17, 14, and 10°C, hypothermia develops (35-21°C), which increases as a function of the environmental heat decreases; the plasma free fatty acid content, which decreases in restrained animals at 23°C and 19°C ($P<0.001$) is not modified at 17, 14, and 10°C; glycemia, which increases at 23°C ($P<0.001$), decreases by 15-20% in rat immobilized at 19, 17, and 14°C and by 70% in those immobilized by 10°C.

b. Rats kept at 10°C before immobilization. Restraint applied at 10°C causes hypothermia of 21°C; it does not modify the plasma free fatty acid content and causes a 50% reduction of glycemia: the latter decreased from 0.90 mg/ml to 0.44 mg/ml.

Discussion

To facilitate the discussion we have tabulated (see above) the main results obtained from rats subjected to restraint

stress, associated and not associated with a reduced environmental temperature stress.

Lipid Metabolism

It is known that the decrease in ambient temperature is a stress which causes stimulation of lipolysis in the free animal [7 - 12].

Under our experimental conditions we found that when the free rat is kept for two and a half hours in 10°C the free fatty acids increase by about 20%, accompanied by very slight hypothermia. In rats restrained at 28, 22, and 19°C, which maintains their normal temperature, or which have slight hypothermia, the plasma free fatty acid content is significantly decreased (Fig. 2.) while at lower temperatures, (17, 14, and 10°C) the restraint, accompanied by greater hypothermia, does not change the free fatty acid content. The constancy under these conditions of plasma free fatty acid content could be explained by compensation phenomonen between the influence of restraint and the influence of cold, stresses of different types exerting reverse effects, of the same order of magnitude, on lipid metabolism. However, as we suggested before [13] these results confirm the fact that restraint is not involved in lipolysis blockage.

To dissociate the effects of the two stresses we kept the animals at 10°C for ten days before immobilizing them at the same temperature for two and a half hours; the results obtained under these conditions are more difficult to interpret. The free animals, exposed to cold for ten days, seemed to have adapted as they exhibit neither hypothermia nor an increase of the plasma free fatty acid content; on the other hand, no sign of adaptation appears in restrained rats with the same heat regulation and lipid metabolism disturbance, whether they were kept at 10°C before restraint or not.

Glucide Metabolism

The decrease in environmental temperature causes hyperglycemia in the rat at normal temperature [10]; in hypothermal animals, on the other hand, both hyperglycemia [14, 15, 16] and hypoglycemia [17, 18, 19] have been observed. As Savy [16] commented, it is probable that the techniques for obtaining hypothermia, the rate of cooling, and the degree of hypothermia are responsible for the contradictory results obtained by different authors. /1282

In our work, the two and a half hour restraint at different ambient temperatures may or may not be accompanied with hypothermia; where hypothermia exists it appears slowly and progressively [2]. The repercussions on glucide metabolism vary according to ambient temperature and the degree of hypothermia: hyperglycemia in rats with normal temperature or slightly hypothermal rats after restraints at 28 or 22°C; hypoglycemia in hypothermal rats after immobilization at ambient temperatures of 19°C or less. As a result, although exposure to cold and restraint both cause hyperglycemia, the combination of the two, which makes the rat hypothermal, causes a drop in the blood glucose content. The most pronounced glycemia drop (60% on the average) occurs with the greatest hypothemia (21°C).

For animals kept for ten days at 10°C the glycemia is changed only in the free rats adapted to this ambient temperature; on the other hand, strongly hypothermal rats restrained for two and a half hours exhibit considerable hypoglycemia, identical to the situation with animals restrained for two and a half hours without having been kept previously in this environment.

CONCLUSIONS

The effects on lipid and glucide metabolism of two stresses, singly or in combination -- restraint and some variation in

environmental temperature -- are studied in the rats.

1. A decrease of ambient temperature causes an increase in the plasma free fatty acid content and hyperglycemia accompanied by negligible hypothermia in the free rat.

2. Restraint in animals kept at ambient temperatures close to that of their normal environment causes a drop in the plasma free fatty acid content and an increase in glycemia, while the rectal temperature varies only slightly.

3. A combination of the two stresses, restraint and cooling, causes no modification to the plasma free fatty acid content but brings about extreme hypoglycemia accompanied by pronounced hypothermia.

4. The metabolic effects of the two stresses and their interferences are discussed.

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